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Feature Article

Study on the Distribution and Habitat Characteristics of the Chinese Grassbird (*Graminicola striatus*, 大草鶯) in Hong Kong

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漁農自然護理署鳥類工作小組於2011年夏季進行一項有關大草鶯*(Graminicola striatus)* 的生態研究，發現大草鶯於本港的分布與舊有記錄相似，估計現時本港的大草鶯數目約有490隻，其生境於三月至九月主要為海拔200米以上、長度及密度高的草地，而芒屬則是其生境中覆蓋率最高的植物。

Background

The Chinese Grassbird (*Graminicola striatus*, 大草鶯) (Fig. 1) is a newly recognised species that has been split from the Indian Grassbird (*G. bengalensis*; formerly known as the Rufous-rumped Grassbird). The split of the grassbirds, which was proposed in 2010 based on a morphological, vocal and genetic study (Leader et al., 2010), was recently accepted by the International Ornithologists' Union in January 2012 (Gill & Donsker, 2012).

Fig. 1. The Chinese Grassbird.

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At present, the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (世界自然保護聯盟瀕危物種紅色名錄) lists the Rufous-rumped Grassbird (referring to both the Chinese Grassbird and the Indian Grassbird as the recent split has yet been accounted for in the Red List assessment) as Near Threatened (BirdLife International, 2008). The global population of the Rufous-rumped Grassbird was estimated at 10,000-19,999 mature individuals with a declining trend due to severe degradation of grassland habitats (BirdLife International, 2012). In connection with the recent taxonomic changes, the conservation status of both the Chinese Grassbird and the Indian Grassbird shall be revised. It is believed that the status of both species shall at least remain unchanged or probably be revised to a threatened category (Critically Endangered, Endangered or Vulnerable); the global population size of both species requires revision as a result of the taxonomic change and the further restriction of the geographic range of both species after the split. The Chinese Grassbird can be found in Myanmar, Vietnam (presumed locally extinct), Thailand (presumed locally extinct) and China (Hainan Island, Guangxi and Guangdong), while the Indian Grassbird is distributed in India, Bangladesh and Nepal (del Hoyo et al., 2006; BirdLife International, 2012).

In Hong Kong, the Chinese Grassbird has been observed at least since 1957 at Tai Mo Shan. However, it was considered to be the Brown Prinia (*Prinia polychroa*, 褐山鷦鶯) until an individual was caught and identified as a Rufous-rumped Grassbird in 1982 during bird netting activity (Melville and Chalmers, 1984). The recent taxonomic revision has confirmed the grassbird occurring in Hong Kong as the Chinese Grassbird.

Information on this scarce resident in Hong Kong is limited. It was considered to be a grassland specialist breeding above 500 m that would descend to lower altitudes in the winter (Carey et al., 2001; Viney et al., 2005). Nevertheless, recent sightings showed that the Chinese Grassbird also occurs at lower altitudes in the summer. Recent literature also regards the species as generally occurring at 200–800 m or simply above 200 m (Leader et al., 2010; Carey et al., 2011). Since there is no recent record of this species in Myanmar, Vietnam and Thailand, and only two recent records in China outside of Hong Kong, the population in Hong Kong appears to be the only known stronghold of the species. After the revision of its conservation status, the Chinese Grassbird could become the only native breeding bird species listed as threatened in the IUCN Red List in Hong Kong.

Previous ecological studies of the Rufous-rumped Grassbird have turned out to be studies on the Indian Grassbird (e.g. Baral et al., 2006). This has left the Chinese Grassbird as one of the least studied species with conservation concern. As Hong Kong is the only known breeding ground of this species with regular records, studies on the Chinese Grassbird in Hong Kong would be very valuable to better understand the ecology of the species.

Objectives

Local information on the Chinese Grassbird is mostly limited to sighting records. Therefore, a systematic survey was carried out to update the latest local distribution of the species, to estimate the local population size and to characterise the vegetation of its preferred habitats.

Methods

Bird Survey

Surveys were carried out from March to September 2011. The period covered the breeding season of the Chinese Grassbird from late April to early July (Carey et al., 2001), during which the species could be detected more easily. With reference to the Agriculture, Fisheries and Conservation Department's (AFCD) biodiversity database and the local literature (e.g. Carey et al., 2001), eleven sites with previous summer records of the species were selected for the survey. The study sites were Fei Ngo Shan, Grassy Hill, Lantau Peak, Lin Au, Ma On Shan, Nei Lak Shan, Pat Sin Leng, Robin's Nest, Sunset Peak, Tai Mo Shan and Tai To Yan.

Each study site was visited twice during the study period. Transects were set in each study site. Counting points, with an inter-point distance of 250 m, were fixed along the transects. A point count was conducted at each counting point for 10 minutes. The number of Chinese Grassbirds observed and/or heard at the counting points or along the transects was recorded. The half-width of the transect and the radius for the point count was set at 50 m since it has been shown that 60% of grassland birds can be missed by surveyors at a distance greater than 50 m (Diefenbach et al., 2003). The altitude of the survey transects ranged from 200 m to 934 m. Due to variations in the intrinsic characteristics of the study sites, the transects at each site were of different shapes and lengths.

Surveys were only conducted on days with fine weather to minimise differences in the detectability of birds under different weather conditions. The survey time was set in the early morning when birds are more active.

Habitat Characteristics

Habitat characteristics including altitude, percentage cover of vegetation, visual obstruction and maximum vegetation height were recorded. These measurements were taken at localities where Chinese Grassbirds were recorded. At each of these localities, five sampling points were randomly chosen within a 100 m x 100 m quadrant. All measurements were taken at each of these five sampling points.

The percentage cover of different vegetation types and plant species present were evaluated in the field with a 20 cm x 50 cm Daubenmire frame (Daubenmire, 1959) (Fig. 2). Daubenmire frame is widely used to quantify the percentage cover of vegetation in grassland bird studies (Bajema et al., 2001; Fritcher et al., 2004; Winter et al., 2005). When using the Daubenmire frame, the percentage cover of vegetation is recorded in six classes (Table 1). The mid-points of the percentage cover of each class, instead of the absolute percentage cover, were used for data analysis. The Daubenmire frame was used in this study as it is a simple and rapid method for quantifying vegetation cover. Additionally, discrepancies in the measurements taken by different surveyors are minimised using the six-class classification scheme.

Fig. 2. Daubenmire frame used to measure the percentage cover of vegetation.

Table 1. Cover classes of vegetation when using a Daubenmire frame.

Class	Range of percentage cover (%)	Mid-point of percentage cover (%)
1	0-5	2.5
2	5-25	15.0
3	25-50	37.5
4	50-75	62.5
5	75-95	85
6	95-100	97.5

In this study, vegetation was classified into four types, i.e. grass, bamboo, ferns and woody vegetation. Bamboo referred to plants belonging to the subfamily Bambusoideae of Poaceae (Grass Phylogeny Working Group, 2001), grass referred to plants of the family Poaceae except bamboo, ferns referred to Pteridophytes and woody vegetation referred to shrubs or trees according to the Check List of Hong Kong Plants (Hong Kong Herbarium, 2004). All plant species were identified to the species level as far as practicable.

Visual obstruction measurements, which reflect the density of standing vegetation, were taken using a Robel pole (Robel et al., 1970). This method is commonly used in grassland bird studies (e.g. Bajema et al., 2001; Fritcher et al., 2004). The Robel pole was prepared according to Toledo et al. (2008). It is a pole painted with alternating colours at 10 cm intervals. During the measurement, the Robel pole is placed vertically on the ground, 4 m away from the observer. The observer, with a sighting pole (a pole with an observation hole 1 m above the ground), measures the height of the band on the Robel pole which is completely obscured by vegetation. (Fig. 3).

The maximum vegetation height was measured as the height of the tallest plant at rest within each Daubenmire frame to the nearest 5 cm. Altitude was taken using GPS.

Fig. 3. An observer (left), through the sighting pole, is taking a visual obstruction measurement with a Robel Pole (right).

Data Analysis

In order to avoid possible double counting at each study site, the highest single day count at each site was used when analysing the number of Chinese Grassbirds recorded. The Pearson product moment correlation was used to examine the correlation between bird density and altitude.

Results and Discussion

Distribution of the Chinese Grassbird in Hong Kong

The Chinese Grassbird was recorded in nine of the eleven study sites. Although the species was not recorded at Lin Au and Grassy Hill in this study, it was observed at both sites within the six-month survey period by other AFCD staff (Fig. 4).

Almost all sites with published summer records of Chinese Grassbirds were included in this study. On the other hand, Lin Au was not a published site but was recorded with Chinese Grassbirds in March 2009 by the AFCD. The species was observed at all study sites either during or outside the surveys within the six-month survey period. This showed that the distribution of the Chinese Grassbird, at least during the summer, is similar to the published records. All sites except Robin's Nest are located inside Country Parks, while the designation of Robin's Nest as a Country Park is underway.

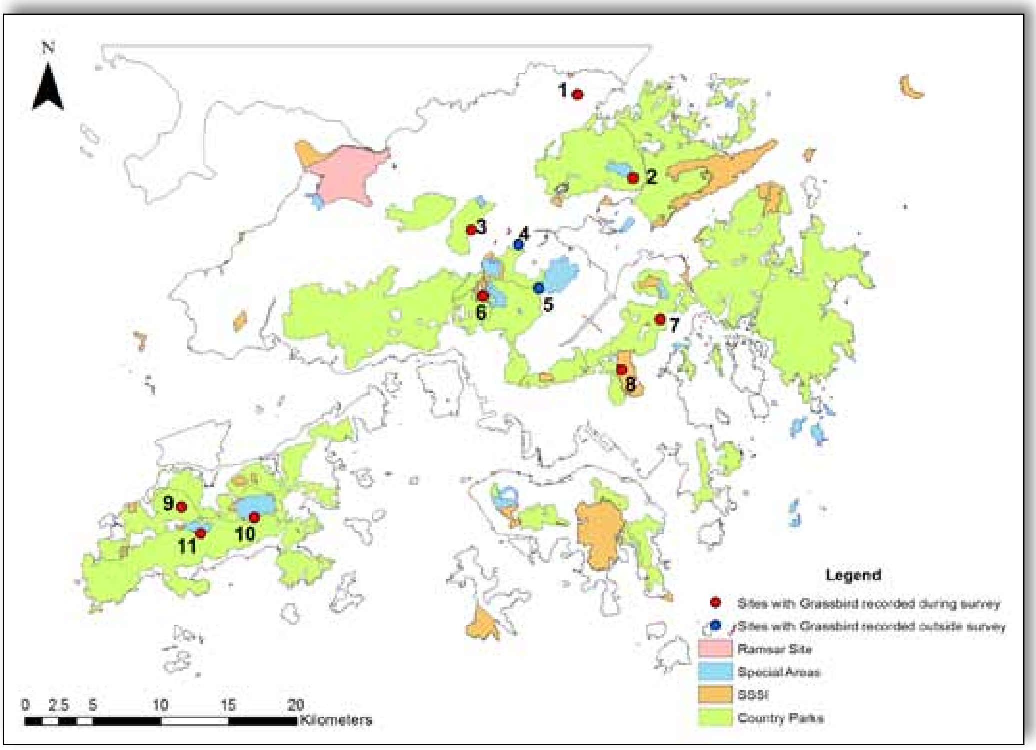


Fig. 4. Distribution map of the Chinese Grassbird recorded between March and September 2011.

1: Robin's Nest; 2: Pat Sin Leng; 3: Tai To Yan; 4: Lin Au; 5: Grassy Hill; 6: Tai Mo Shan; 7: Ma On Shan; 8: Fei Ngo Shan; 9: Nei Lak Shan; 10: Sunset Peak; 11: Lautau Peak

Density and Estimated Local Population of Chinese Grassbirds

Using the highest single day count and assuming individuals were not double counted, a total of 24 Chinese Grassbirds were recorded during the study (Table 2). The highest number of Chinese Grassbirds recorded in a single day was at Sunset Peak (five birds), probably due to the longest transect surveyed. No birds were recorded at Lin Au and Grassy Hill in this study. The highest number of Chinese Grassbirds recorded at any one time was three birds at a point count station at Tai Mo Shan.

Table 2. Estimated density of Chinese Grassbirds at each study site.

Site	Highest Single Day Count	Transect Area Covered (ha)	Density (bird/ha)
Tai Mo Shan	4	14.17	0.28
Robin's Nest	3	15.91	0.19
Sunset Peak	5	28.32	0.18
Nei Lak Shan	2	11.39	0.18
Fei Ngo Shan	2	11.55	0.17
Lautau Peak	3	24.65	0.12
Ma On Shan	2	17.73	0.11
Pat Sin Leng	2	17.40	0.11
Tai To Yan	1	19.22	0.05
Grassy Hill	0	14.98	0.00
Lin Au	0	4.07	0.00
Total	**24**	**179.39**	**Average: 0.13**

The density of Chinese Grassbirds was estimated with the assumptions that all Chinese Grassbirds were recorded during the survey and they were evenly distributed at the survey site. The highest density of Chinese Grassbirds was recorded at Tai Mo Shan (0.28 bird/ha). Although the lowest altitude where the species was recorded in this study was at 384 m, the total transect area covered by this study (from 200 m of altitude upward) was used to calculate the average densities of Chinese Grassbirds. This is because the Chinese Grassbird is thought to occur above 200 m (Carey et al., 2011) and was observed at about 200 m at Lin Au by AFCD staff during the six-month survey period. The average densities of Chinese Grassbirds above 200 m was 0.13 bird/ha, which was a three-fold higher density than that estimated by Leader et al. (2010) (0.02-0.04 bird/ha).

An estimation of the local population of Chinese Grassbirds was made using the density data and estimated area of grassland above 200 m in Hong Kong obtained from the 'Terrestrial Habitat Mapping and Ranking Based on Conservation Value' study (Environmental Resources Management, 2010). In addition to the two assumptions in calculating Chinese Grassbird densities stated above, the estimation of the Chinese Grassbird population also assumed that the grassland habitat defined by Environmental Resources Management (2010) was suitable for the species and the species was evenly distributed in this habitat. It was therefore estimated that the local population size of Chinese Grassbirds was 490 birds. This estimation was at least 2.5 times higher than the population size estimated by Leader et al. (2010) (50–100 pairs).

Habitat Characteristics

Throughout the study (two visits to each study site), a total of 35 Chinese Grassbirds were recorded at 18 localities among the 11 sites. Habitat characteristics were measured at all of the 18 localities.

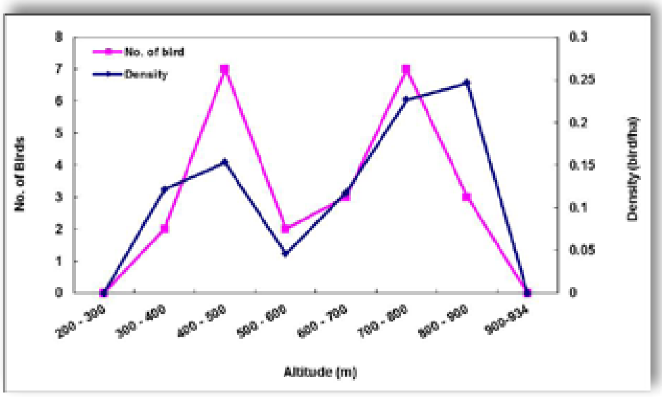
Altitude

Of all the records taken during the survey, the Chinese Grassbird occurred at altitudes of 384 m to 822 m. Given that the Chinese Grassbird was observed at about 200 m at Lin Au during the survey period, the altitudinal range of the species fitted the description of above 200 m by Carey et al. (2011). Nevertheless, it should be noted that habitats below 200 m were not surveyed in this study.

When using the highest single day count data, the greatest number of birds (seven) occurred at 400–500 m and 700–800 m, while no birds were recorded at the lowest and highest altitudes, i.e. 200–300 m and 900–934 m (Fig. 5). The density of the Chinese Grassbird was highest at 800–900 m (0.25 bird/ha) and lowest at 200–300 m and 900–934 m (0.00 bird/ha). Both the pattern of number of birds and bird density showed a trough at 500–600 m. Nevertheless, no significant correlation was found between the density of Chinese Grassbirds and altitude ($r = 0.28$, $P = 0.50$).

It has been stated that Chinese Grassbirds breed above 500 m and may descend to lower altitudes in the winter (Carey et al., 2001; Viney et al., 2005). Nevertheless, a relatively high density of this species was recorded at 300–500 m in the present study. The records at Lin Au in July 2011 (AFCD internal record) and at Heung Yuen Wai in May 2007 (Carey et al., 2011) also suggest that the species may breed or be present at lower altitudes during the summer months.

Fig. 5. Number and density of Chinese Grassbirds recorded at different altitudes.



Percentage Cover of Different Vegetation Type

Grass was found to be the most abundant vegetation type in the habitat of the Chinese Grassbird. All 18 localities (100%) had grass cover. The percentage of grass cover (47.5–97.5%; mean: 74.2%) was also the highest among the four vegetation types in all localities. Sixteen (88.9%) localities had woody vegetation cover and 11 (61.1%) had ferns. Both woody vegetation (0.0–13.5%; mean: 6.7%) and ferns (0.0–20.0%; mean: 4.3%) made up a relatively small percentage cover of vegetation. Bamboo was only recorded at one (5.6%) locality (percentage cover: 0.0–17.0%; mean: 0.9%).

As previously described, the habitat of the Chinese Grassbird is rich grassland (Carey et al., 2011). The results of the present study largely fit with this description. The possible reasons for this preference for grass may be due to the availability of food sources and nesting sites for this species. Nevertheless, it should also be noted that instead of preferring a pure grassland stand, the Chinese Grassbird appeared to prefer grassland habitat with some woody vegetation or ferns (Fig. 6). Although bamboo was only recorded at one of the localities surveyed, it made up a significant percentage cover at another locality at Grassy Hill where the Chinese Grassbird was observed outside the survey. The Kadoorie Farm and Botanical Garden (2009) also concluded that a habitat of long grasses and dwarf bamboo might be a suitable foraging or nesting habitat for the species. Hence, the possible significance of bamboo as a habitat for the Chinese Grassbird should be noted.

Fig. 6. Typical habitat of the Chinese Grassbird observed in the present study.

Percentage Cover of Different Plant Species

A total of 22 species of plants were recorded at the 18 Chinese Grassbird localities. These included three grass species, five fern species, thirteen woody plant species and one bamboo species (Annex 1).

The most common plant species recorded was *Miscanthus* species (芒屬), which was found at 17 localities (94.4%). Present at seven localities (38.9%), *Dicranopteris pedata* (芒萁) was the second most common plant and the most common fern recorded. *Melastoma malabathricum* (野牡丹) and *Rubus reflexus* (鏽毛莓) were the third most common plant and the most common woody vegetation (Fig. 7). Both were recorded at six localities (33.3%).

In terms of percentage cover, *Miscanthus* species was the most dominant species (mean: 68.6%). The second most dominant species was *Ischaemum* species (鴨嘴草屬) (4.9%), while the third was *D. pedata* (3.9%), followed by *M. malabathricum* (2.1%) and *R. reflexus* (1.6%).

Most of the plant species recorded in this study are common and widespread in Hong Kong. The commonness and high percentage cover of *Miscanthus* species reflected its importance to the Chinese Grassbird. In Hong Kong, grassland dominated by *Miscanthus* species is common throughout the countryside (Hu and Wu, 2011). It is also widely distributed throughout South China. In view of the recent records of the Chinese Grassbird in Guangdong and Guangxi (Lee et al., 2006), it is possible that the distribution of the bird could be wider than the present estimation. Further surveys in this type of habitat could provide a more complete picture of the status of the Chinese Grassbird in South China.

Fig. 7. Common and dominant plant species recorded in the habitat of the Chinese Grassbird: (a) *Miscanthus* species; (b) *Dicranopteris pedata*; (c) *Melastoma malabathricum*; and (d) *Rubus reflexus*.

(a)

(b)

(c)

(d)

Vegetation Height and Visual Obstruction Measurement

The maximum vegetation height of Chinese Grassbird habitats ranged from 75–166 cm (mean: 120 cm) while visual obstruction measurements ranged from 44–162 cm (mean: 94 cm). These results show that Chinese Grassbirds prefer habitats with tall (more than a metre high) and dense grasses, which is similar to the preferences of the Indian Grassbird (Baral et al., 2006).

Other Observations

Diet

Due to the taxonomic revision of the Rufous-rumped Grassbird, existing information on the diet of the species were more applicable to the Indian Grassbird. A detailed record on the food items of the Chinese Grassbird is not available. During the surveys, the Chinese Grassbird was observed carrying a spider and an unidentified brown larva in its mouth on separate occasions (Fig. 8).

Fig. 8. A Chinese Grassbird carrying a spider.

Breeding Activity

The Chinese Grassbird has been recorded breeding at Tai Mo Shan, Sunset Peak, Fei Ngo Shan and Tai To Yan (Carey et al., 2001). Other than these records, the only information concerning the breeding of the species was a report of a nest with four young birds observed in 1979 (Melville & Chalmers, 1984).

During the present survey, possible nest attending behaviour was observed at Sunset Peak. Two individuals were seen returning to a particular spot after foraging. One of the birds was carrying food in its mouth (Fig. 9). The pair flew out from and returned to the possible nesting site twice during a one-hour observation period. While heading back to the possible nest after foraging, they made several short-distance flights instead of flying straight back to the nest.

Fig. 9. A Chinese Grassbird returning to a possible nest with a food item in its bill.

The Return of the Chinese Grassbird After Site Regeneration

The Chinese Grassbird has been recorded annually since 2008 at Robin's Nest (AFCD internal record). However, a hill fire burnt out a huge extent of the grassland there shortly before the study began. Our visit in March 2011 did not record any Chinese Grassbirds and most of the grasses had not yet regenerated. Despite the fire, three individuals were found during the second visit in June after the grasses had regenerated (Fig. 10). The localities of the birds were close to those recorded in the previous year.

Substratum for Perching

While the Indian Grassbird was observed to perch on grasses only (Baral et al., 2006), the Chinese Grassbird was seen perching on woody vegetation (Fig. 10) and rocks in addition to grasses during the surveys.

Conclusion and the Way Forward

The present study shows that the distribution of the Chinese Grassbird is similar to the published records. Almost all sites with records of the species are well-protected inside Country Parks. The density of Chinese Grassbirds was estimated at 0.13 birds/ha while the population was estimated at 490 individuals. From March to September, the Chinese Grassbird preferred tall, dense grassland dominated by *Miscanthus* species, with some woody vegetation or ferns above 200 m in altitude. These habitat preferences should be considered when managing grasslands for the Chinese Grassbird.

This study is the first systemic ecological study on the Chinese Grassbird in Hong Kong. In view of the possible need for conservation concern with this species, any additional information on its ecology would be valuable. Further study on its distribution during the non-breeding season, prey items, territory size and breeding ecology would be important for the conservation of this species.

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Fig. 10. Robin's Nest (a) after a hill fire in March 2011 and (b) after the regeneration of vegetation in June 2011.

(a)

(b)

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Annex 1. List of plant species recorded at localities with the Chinese Grassbird.

Plant Species	Vegetation Type*	Localities#																	
		FNS	LP-1	LP-2	MOS-1	MOS-2	NLS	PSL-1	PSL-2	RN-1	RN-2	SP-1	SP-2	SP-3	SP-4	TMS-1	TMS-2	TMS-3	TTY
Arundinella setosa (刺芒野古草)	G									✓									
Ischaemum sp. (鴨嘴草屬)	G					✓					✓								
Miscanthus sp. (芒屬)	G	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Indocalamus longiauritus (箬葉竹)	B																	✓	
Blechnum orientale (烏毛蕨)	F		✓										✓						
Dicranopteris pedata (芒萁)	F	✓			✓		✓	✓			✓					✓	✓		
Lygodium japonicum (海金沙)	F							✓		✓									
Palhinhaea cernua (鋪地蜈蚣)	F			✓															
Pteris ensiformis (劍葉鳳尾蕨)	F									✓									
Aporusa dioica (銀柴)	W				✓														
Clerodendrum fortunatum (白花燈籠)	W		✓				✓												
Desmodium heterocarpon (假地豆)	W				✓														
Embelia laeta (酸藤子)	W										✓								
Litsea rotundifolia (圓葉豺皮樟)	W																		✓
Melastoma malabathricum (野牡丹)	W	✓	✓					✓		✓	✓	✓							
Millettia nitida (亮葉崖豆藤)	W						✓												
Rhamnus crenata (長葉凍綠)	W																		✓
Rhodomyrtus tomentosa (桃金娘)	W							✓								✓			
Rubus reflexus (鏽毛莓)	W			✓		✓			✓				✓	✓			✓		
Smilax china (菝葜)	W															✓			
Symplocos sumuntia (山礬)	W												✓	✓			✓		
Syzygium buxifolium (赤楠)	W												✓						

* G: Grass; B: Bamboo; F: Fern; W: Woody vegetation

FNS: Fei Ngo Shan; LP: Lantau Peak; MOS: Ma On Shan; NLS: Nei Lak Shan; PSL: Pat Sin Leng; RN: Robin's Nest; SP: Sunset Peak; TMS: Tai Mo Shan ; TTY: Tai To Yan

Experimentation on the Use of Bat Boxes in Hong Kong

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漁農自然護理署哺乳動物工作小組在過去五年進行了不同類型蝙蝠箱的測試，本文報導有關測試的結果，當中包括使用蝙蝠箱的蝙蝠品種、季節性的使用情況、蝙蝠箱大小及顏色對蝙蝠箱使用率的影響。

Introduction

Bat boxes are artificial roosts which are designed to provide alternative roosting sites for bats. They have been widely used in bat conservation programmes, such as habitat enhancement by providing additional roosting sites to increase bat populations (Stebbings & Walsh, 1991; Tuttle & Hensley, 1993) and as ecological mitigation measures to offset the impact of development on bats (Whitaker et al., 2006; Brittingham & Williams, 2000). They are also used as educational tools to involve the general public in bat conservation (Pennisi et al., 2004). Insectivorous bats consume a large number of moths, beetles and other insects at night and, therefore, bat boxes are also erected on agricultural lands, especially on organic farms, for pest control (Kiser, 1997).

Unlike bird or squirrel boxes, the entrance of bat boxes is in the form of a narrow gap and is usually connected to a vertical platform which allows bats to land and crawl inside quickly. Bat boxes may take different shapes and sizes to mimic the natural roosting habitats of different bat species. The testing of bat boxes has been undertaken in different parts of the world (Stebbings & Walsh, 1991; Tuttle and Hensley, 1993; Lourenco & Palmeirim, 2004). In terms of box designs, there are a number of factors affecting the success or the occupancy of bat boxes, such as colour, size, the presence of a landing board and the number of partitions inside the box. Painting the box may help regulate the internal temperature by absorbing or reflecting solar radiation. According to Tuttle and Hensley (1993), it is recommended to paint bat boxes black in cooler regions where the average daily maximum temperature in July is less than 30ºC. This is because the black surface absorbs more solar energy which heats up the box. In hotter regions where the average daily maximum temperature in July exceeds 37ºC, the opposite is recommended, i.e. boxes should be painted white. However, in the hot Mediterranean region, black boxes were occupied by more bats than those painted grey or white, as the nursery colonies of bats prefer warm roosts with temperatures up to 40ºC (Lourenco & Palmeirim, 2004). Roosting temperature plays an important role in bat box occupancy, as both females and pups roost at the warmest location in their roost to conserve energy during pregnancy, lactation and growth (Tuttle & Hensley, 1993). On the other hand, in winter, hibernating individuals prefer white boxes as the boxes provide a more stable roosting temperature by reflecting solar energy.

Besides colour, the size of bat boxes is also important in determining their suitability as a roost site for bats. A nationwide bat box project, the 'North American Bat House Research Project', established by Bat Conservation International (BCI) in 1993, showed that larger boxes provide greater temperature gradients and therefore, better accommodate bats at different physiological stages, such as pregnancy, young rearing and hibernation. These results also suggest that some bats prefer tight spaces in their roosts and therefore, bat boxes with multiple narrow roosting partitions had a higher occupancy rate. Meanwhile, in the U.K., Stebbings and Walsh (1991) proposed a simple design employing a square wooden box with a single large roosting chamber which was found to be an effective artificial roost for many European bat species.

Among the 26 species of bats recorded in Hong Kong, species that predominantly roost in buildings, such as some species of *Pipistrellus, Nyctalus* and *Scotophilus*, are potential bat box residents (Tuttle & Hensley, 1993). However, *Pipistrellus abramus* (Japanese Pipistrelle, 東亞家蝠) is the only species reported to utilise bat boxes in Hong Kong (Dahmer, 2002; Ades, 2004; Chan, 2006). Also, little information is available on the design of boxes that best attracts bats in Hong Kong under local conditions. This study aimed at comparing the preference of local bat species on different designs of bat boxes, especially in terms of colour and size.

Materials and Methods

Bat Boxes

Large BCI box: This was adopted from the Nursery House Model designed by BCI (Tuttle & Hensley, 1993). The design was composed of four narrowly partitioned chambers (Fig. 11) and was made out of marine-grade plywood. The dimensions were L 79 × W 44 × D 13.5 cm with four roosting chambers (L 44.5 × W 44 × D 2 cm). While some of the boxes were painted black, grey and white for colour preference comparison, some were painted dark green for the size preference comparison.

Table 3. Number of bat boxes installed at the HKWP, MPMNR and YLBF.

Month Installed	Site	Bat Box	Remark
March 07	HKWP (1 set), MPMNR (3 sets), YLBF (1 set)	5 sets of large BCI boxes in white, grey and black	Colour preference comparison, 2 sets in MPMNR were relocated in August 2009
October 07	HKWP	4 sets of small and large BCI boxes	Size preference comparison
November 07	HKWP	2 small BCI boxes	Attached to trees
August 08	HKWP	2 small BCI boxes & 2 European boxes	Attached to trees
	MPMNR	3 small BCI boxes	Attached to trees, 1 box was removed in December 09
December 09	MPMNR (12 boxes) & YLBF (3 boxes)	15 European boxes	Attached to trees, 2 boxes at YLBF were removed in June 10 and March 11.

Small BCI box: This was a smaller version of the large box and was constructed by reducing the height and width of the roosting chambers of the large BCI box by half. The dimension were L 43 × W 28.5 × D 13.5 cm with four roosting chambers (L 26 × W 25 × D 2 cm). All small boxes were painted dark green for the size preference comparison.

European Box: This was adopted from the bat box designed by Stebbings and Walsh (1991). It was made by mixed real wood and was painted black or dark brown. The dimensions were L 28 ×W 21 × D 15.5 cm with a single roosting chamber (L 18× W 15.5 × D 10 cm).

Bat Box Installation and Monitoring

A total of 47 bat boxes were installed at the Hong Kong Wetland Park (HKWP), the Mai Po Marshes Nature Reserve (MPMNR) and the Yuen Long Bypass Floodway Mitigation Wetland (YLBF) (Table 3). For the colour preference comparison, five sets of large BCI boxes in white, grey and black were erected side-by-side (Fig. 11a). For the size preference comparison, four sets of large and small BCI boxes were erected in pairs (Fig. 11b). The boxes were erected on the ground by mounting them on 3 m wooden posts. When attaching bat boxes on trees, boxes (both small BCI boxes and European boxes) were mounted on tree trunks about 3 m above the ground (Fig. 12). Due to construction work at the MPMNR, two sets of boxes for the colour preference comparison were relocated to different sites within the MPMNR in August 2009. The data from August 2009–December 2011 were excluded from the statistical analysis for the colour preference comparison.

Fig. 11. Bat boxes were erected side-by-side. (a) White, grey and black large BCI boxes for the colour preference comparison and (b) Large and small BCI boxes for the size preference comparison.

(a)

(b)

Fig. 12. Bat boxes mounted on tree trucks. (a) Small BCI box and (b) European box.

(a)

(b)

Bat boxes were checked monthly from March 2007 to September 2009 and quarterly from December 2009 to December 2011. The species and number of bats found inside the boxes were recorded. Four-way repeated measures ANOVA was used for comparisons between BCI boxes of different colours and between box sizes, with locations as the subject, colours/sizes, years and seasons as fixed within-subject factors, and sampling visits as replicates.

Results

Up to December 2011, the highest number of bats counted in all the boxes together at any one time was 234 individuals of two bat species in September 2011. The earliest occupancy, which was a small BCI box mounted on a tree at the MPMNR, was six days after installation. *P. abramus* was found to be the most common bat species found in our boxes at all sites (Fig. 13a and 13b). The numbers of *P. abramus* recorded per box ranged from 1 to 30 individuals. Breeding colonies of *P. abramus* were observed from May to June each year. Two individuals of *Scotophilus kuhlii* (Lesser Yellow Bat, 中黃蝠) were found roosting in both small and large BCI boxes at the HKWP (no. of records, n=12) and the YLBF (n=2) since November 2008 (Fig. 13c). Among the 14 records of *S. kuhlii*, it was either a solitary male roosting inside the boxes alone (n=6) or a solitary male sharing the box together with colonies of *P. abramus* (n=8).

Fig. 13. Bats in bat boxes: (a) *Pipistrellus abramus* in a large BCI box, (b) *P. abramus* in a European box and (c) *Scotophilus kuhlii* in a small BCI box.

(a)

(b)

(c)

As the total number of bat boxes varied across the experimental period, the mean number of bats per box (i.e. the total number of bats counted divided by the number of bat boxes present at the field) was used for comparison. In general, the mean numbers of *P. abramus* per box showed marked seasonal and annual fluctuations, from peaks in June to troughs in December each year. There was also a marked increase (265%) from 2.0 bats per box in the first summer (2007) to 5.3 bats per box in the fifth summer (2011) (Fig. 14). In the first two years, the occupancy rate of all boxes, which is defined as the percentage of boxes occupied by bats, also showed some seasonal variation, with peaks in March and troughs in December. Overall, the occupancy of bat boxes increased from 20.0% in March 2007 to 81.3% in March 2009 and dropped after the installation of 15 European bat boxes in December 2009, but rebounded to 79.5% in March 2011.

For the box colour preference comparison, the number of *P. abramus* occupying black BCI boxes was significantly higher than that in the white or grey boxes (four-way repeated measures ANOVA: $F_{2,8} = 7.30$, $p = 0.016$, plus Tukey's test) from April 2007 to August 2009 (Fig. 15). No seasonal difference was detected ($p > 0.05$), although the number of *P. abramus* in the boxes seemed to be higher during the summer (Apr-Sep; Fig. 14). There was also no inter-year difference in the number of *P. abramus* from April 2007 to August 2009 ($p > 0.05$).

Fig. 14. Number of *Pipistrellus abramus* per box and the occupancy rate of all boxes from March 2007 to December 2011.

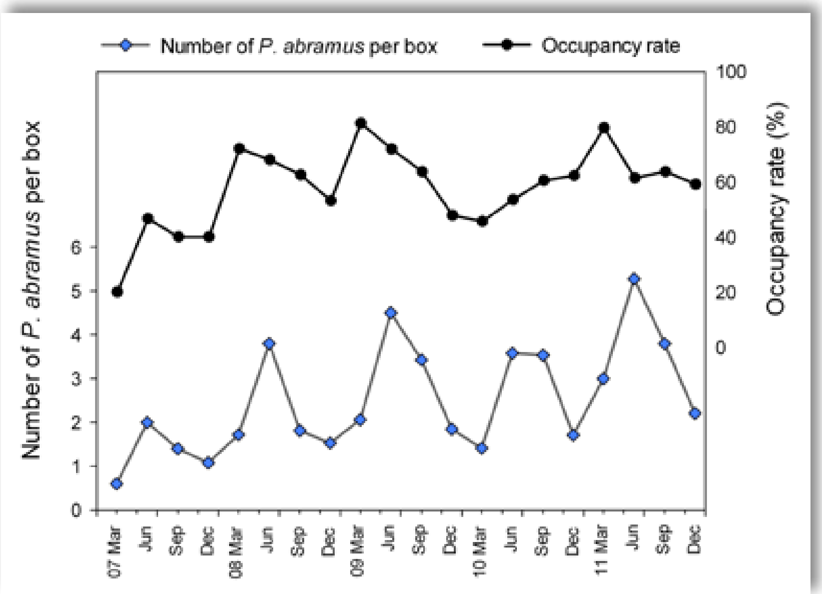
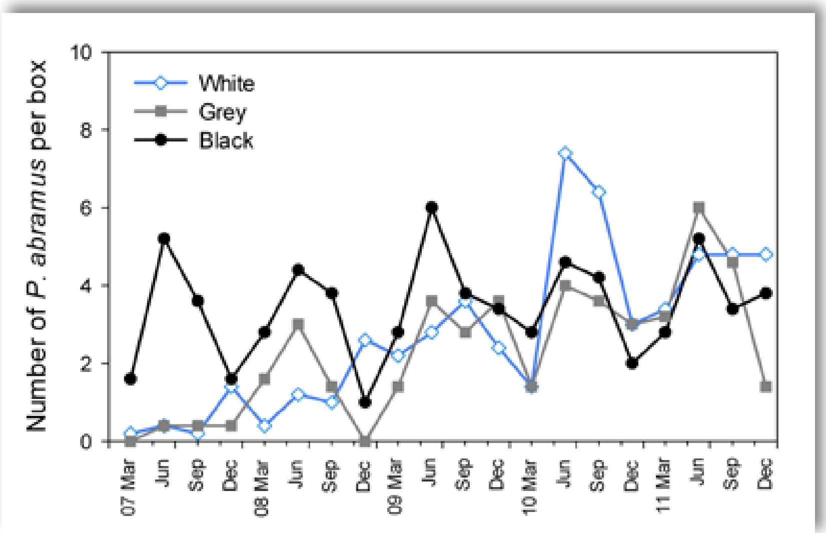


Fig. 15. Number of *Pipistrellus abramus* per box in white, grey and black BCI boxes from March 2007 to December 2011.



For the box size preference comparison, there was no significant difference between the number of *P. abramus* recorded in small and large BCI boxes in the first two years. As the study progressed, there was a significant interaction between box size and year ($F_{4,12}$ = 3.72, p = 0.034), likely due to the increase in *P. abramus* roosting in large boxes and hence a greater difference in bat numbers between the two box sizes over the years (see Fig. 16). Generally, the number of P. abramus in the boxes was higher during the summer (Jun-Sep; $F_{1,3}$ = 44.22, p = 0.007).

Six BCI small boxes and 17 European boxes were mounted on trees to examine the bat's preference for box designs and placement methods. All six BCI small boxes were mounted on trees. They were occupied by bats within two to four months and the mean number of *P. abramus* per box increased by 2.6-fold from the first summer (2008) to the fourth summer (2011) (Fig. 17). Breeding colonies of *P. abramus* were found in three boxes. For the European boxes, one of them installed in August 2008 was quickly occupied by *P. abramus* within two months and breeding colonies of *P. abramus* were observed in three boxes. On the other hand, no bats were found in the other six European boxes installed in December 2009.

Fig. 16. Number of *Pipistrellus abramus* per box in small and large BCI boxes from March 2007 to December 2011.

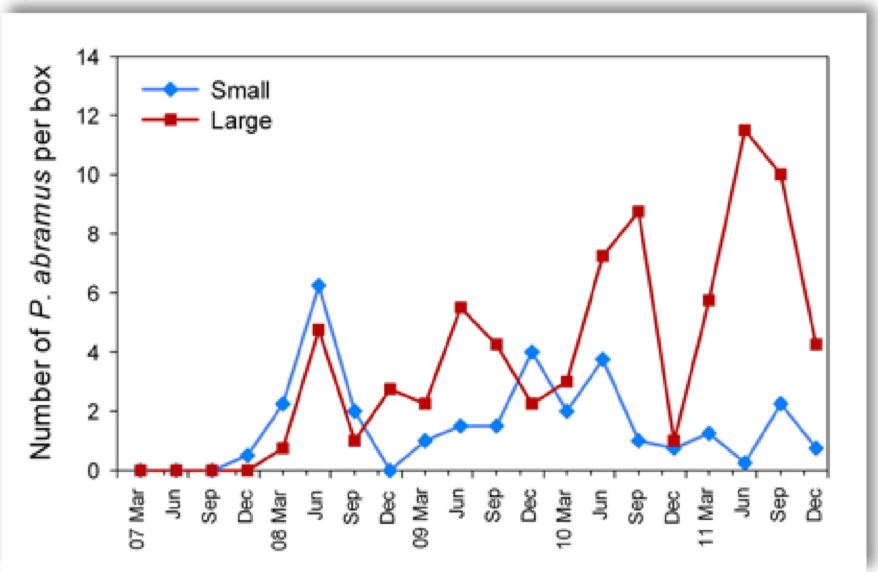
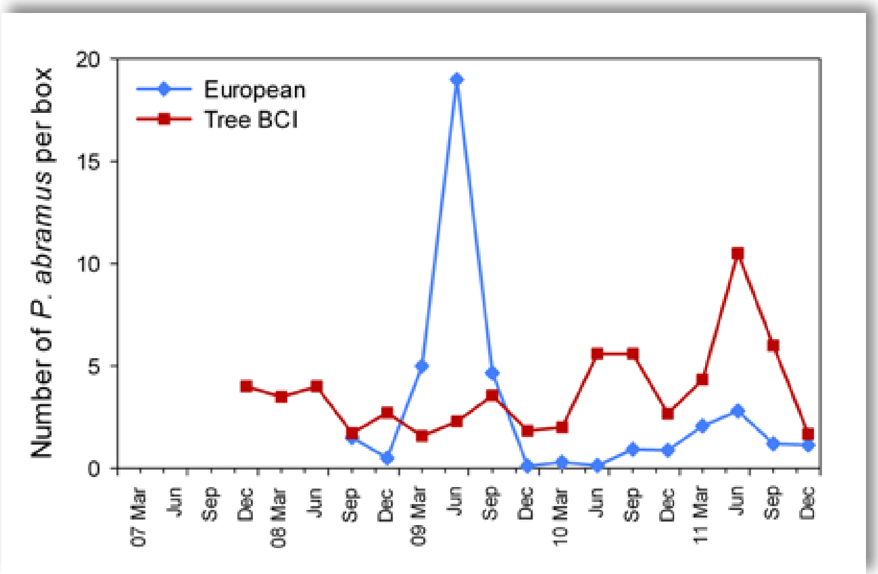


Fig. 17. Number of *Pipistrellus abramus* per box in different box types mounted on trees.



Discussion

This study showed that bat boxes are effective tools to recruit certain bat species in an area by providing alternative roosts. The number of *P. abramus* roosting in the boxes showed a marked increase with seasonal and annual variations over five years. According to the current trend, we expect that more *P. abramus* will use our boxes in the future. However, it cannot be concluded that the bat boxes enhanced the *P. abramus* population as the increased number of bats recorded may simply be attracted from other roosts or areas. In Hong Kong, the roosts of *P. abramus* are found predominantly in buildings as well as bat boxes. They move between roosts throughout the year. The peaks of *P. abramus* roosting in bat boxes in June were due to the formation of maternity or breeding colonies. The low abundance in December may have resulted from some individuals moving to other roosts, e.g. buildings, where the microclimate is relatively more stable in the winter. Nevertheless, more *P. abramus* accepted our boxes as their breeding sites, as 34% of the boxes were recorded with breeding colonies in June 2011, while only about 16% of the boxes had breeding records in June of the previous three years. High occupancy rates of *P. abramus* in all boxes were observed in March of the second, third and fifth years. In overseas studies, high occupancy rates were due to the formation of breeding colonies in bat boxes in the summer (Flaquer et al., 2006), but this high rate in March, which is out of the breeding season in Hong Kong, may be due to other factors which are not well understood.

P. abramus showed a higher preference for black BCI boxes than for the other two colours in the first three years, but the preference changed afterwards. On the other hand, *P. abramus* showed no preference for box size in the first two years, but as the study progressed, it preferred the large BCI boxes over the small ones. The reason for the changes in preference for colours and sizes over time are not known.

Two individuals of *S. kuhlii* were also found using the small and large BCI boxes. This is the first record of this medium-sized bat species roosting in local bat boxes. This house-dwelling species is considered as a heat tolerant species which often finds shelter in attics with extremely high temperatures (Nowak, 1994). In order to provide more roosting places for this uncommon species, our next challenge is to construct new bat boxes which can maintain high temperatures in the roosting chamber.

Mounting boxes on tree trunks is considered the most convenient way to set up bat boxes in the field. Both small BCI and European boxes mounted on trees were able to recruit *P. abramus* for occupancy and breeding. As all boxes mounted on tree trunks were shaded with minimal exposure to direct sunlight, it seems that solar heating is not the major determinant of the use of bat boxes by *P. abramus* under local conditions. In conclusion, smaller boxes, especially BCI boxes, could be good artificial roosts for *P. abramus* in Hong Kong. The boxes could be mounted on trees or poles and painted black to increase occupancy.

Throughout the testing period, occupation of our boxes by animals other than bats was common. Uninvited guests included *Parapolybia varia* (Lesser Paper Wasp, 變側異腹胡蜂), *Polistes olivaceus* (Paper Wasp, 家馬蜂), P. *gigas* (Giant Brown Paper Wasp, 棕馬蜂), *Polyrhachis dives* (Black Tree Ant, 雙齒多刺蟻), *Gekko chinensis* (Chinese Gecko, 壁虎), *Plestiodon chinensis* (Chinese Skink, 石龍子), *Polypedates megacephalus* (Brown Tree Frog, 斑腿泛樹蛙) and spiders. In most cases, bats could coexist with these uninvited guests in the boxes. We only removed the animals (mostly wasps and ants) from the boxes if they fully occupied the boxes or blocked the entrance. In fact, the occupation of uninvited guests may be a possible reason to explain some unexpected results. Further studies on the influence of uninvited guests on the occupancy of bats in bat boxes are recommended.

This is an on-going project. More designs or modifications of bat boxes will be tested under local conditions. Hopefully, we will be able to find box designs which are also suitable for other local bat species, such as *Nyctalus plancyi* (Chinese Noctule, 中國褐山蝠).

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An Estimation of the Current Population Size of the Yellow-crested Cockatoo (*Cacatua sulphurea*, 小葵花鳳頭鸚鵡) in Hong Kong

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漁農自然護理署鳥類工作小組於2011年調查小葵花鳳頭鸚鵡在香港的主要棲息地點及種群數量。本文就上述觀察作簡報。

Introduction

Fig. 18. Yellow-crested Cockatoo (*Cacatua sulphurea*).

The Yellow-crested Cockatoo (*Cacatua sulphurea*; 小葵花鳳頭鸚鵡) (Fig. 18) is endemic to Timor-Leste (東帝汶) and Indonesia, where it is distributed from Sulawesi (蘇拉威西) to the Lesser Sunda Islands (小巽他群島). Its natural population in the wild suffered a drastic decline in the mid-1970s to 1980s, mostly attributable to unsustainable exploitation for the pet trade (BirdLife International, 2001; Cahill et al., 2006). Deforestation and habitat fragmentation have also exacerbated the decline (Walker et al., 2005). With the global population numbering fewer than 7,000 individuals and likely to be shrinking, the global conservation status of the Yellow-crested Cockatoo has been categorised as Critically Endangered in the International Union for Conservation of Nature (IUCN) Red List of Threatened Species since 2000 (BirdLife International, 2010). The Yellow-crested Cockatoo was also transferred from CITES Appendix II to Appendix I in 2005.

The Yellow-crested Cockatoo was first reported in Hong Kong in 1961 (Viney, 1973). It probably originated from released birds (Chalmers, 1986) but was later considered to be self-sustaining (Hong Kong Bird Watching Society, 1998). Their numbers were reported to have slightly increased over the years, with 60 to 100 birds in the late 1990s (Carey et al., 2001), and potentially over 100 birds afterwards (BirdLife International, 2001; Leven & Corlett, 2004). The Bird Working Group of the Agriculture, Fisheries and Conservation Department (AFCD) conducted surveys in 2011 to update the estimated population of this species in Hong Kong.

Method

As the Yellow-crested Cockatoo roosts in flocks (del Hoyo et al., 1997), conducting simultaneous counts at their roosting sites can provide an estimation of population size (Casagrande & Beissinger, 1997). All birds were assumed to be roosting communally during the surveys, and surveyed roosting sites were assumed to have covered the vast majority of the population in Hong Kong.

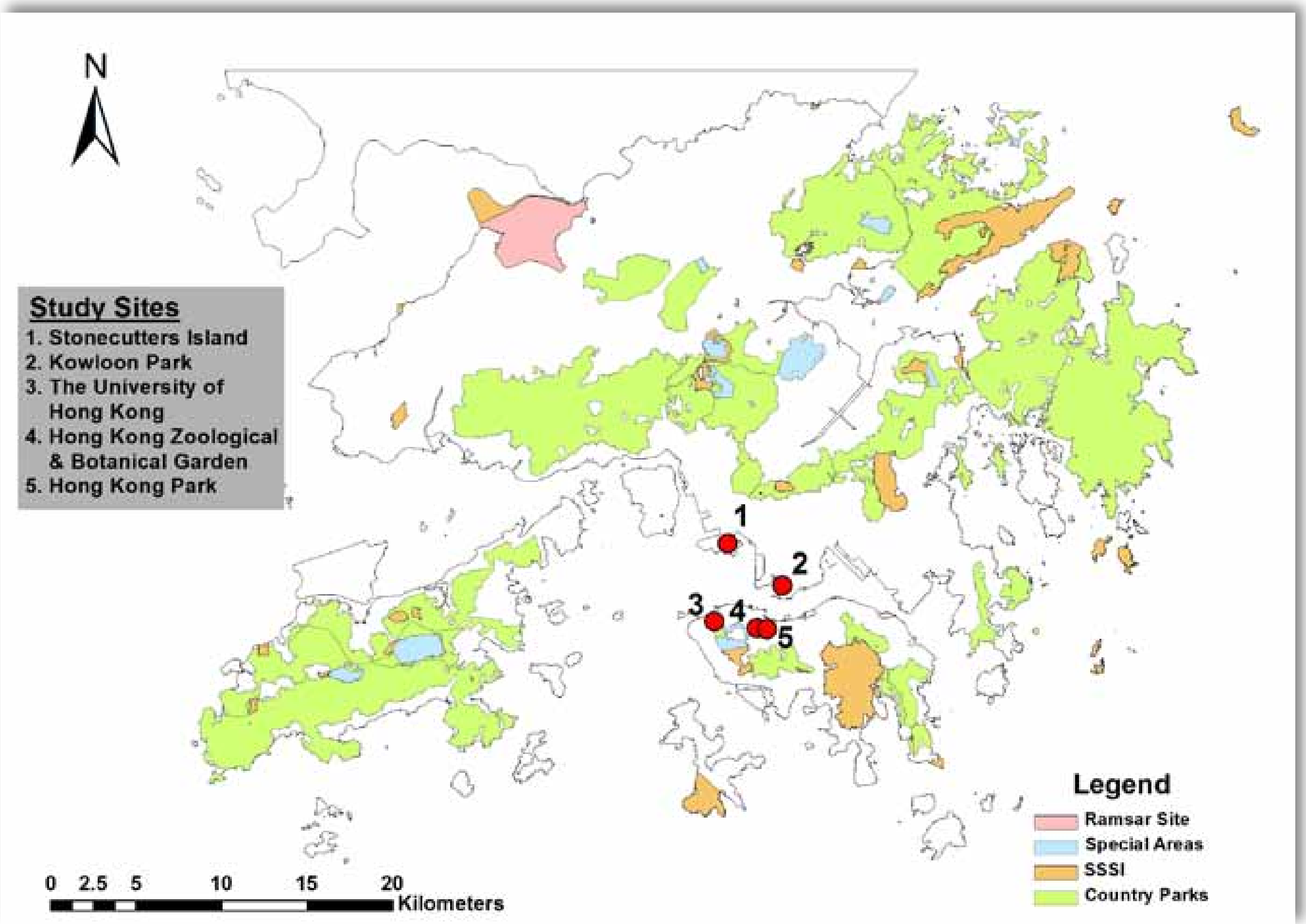
Site Selection

Verification surveys were conducted for three months prior to the actual counting, to locate potential roosting sites where large flocks of cockatoos congregated at dusk. During these surveys, a suitable vantage point was selected at each of the sites overlooking the roost tree(s) or the majority of the site. Two major roosting sites of the Yellow-crested Cockatoo were identified on Stonecutters Island and in Hong Kong Park. Based on these surveys and previous location records of the species, five potential roosting sites were selected for this study (Fig. 19). The selected survey sites included Hong Kong Park (HKP), the Hong Kong Zoological and Botanical Garden (HKZBG), Kowloon Park (KP), Pok Fu Lam Road near the University of Hong Kong (HKU) and Stonecutters Island (SI).

Simultaneous Counts

Simultaneous counts of the Yellow-crested Cockatoo were performed for one and a half hours and were

Fig. 19. Locations of the five survey sites selected for simultaneous roost counts of Yellow-crested Cockatoos at sunset.



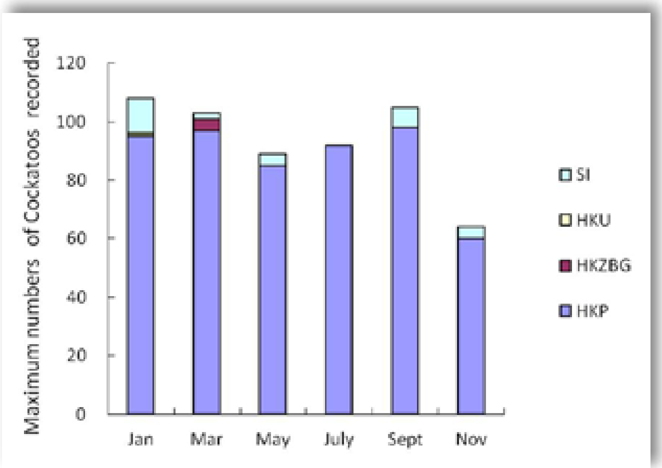
conducted every two months from January 2011 to the end of the year by at least one surveyor at each survey site. The number of Yellow-crested Cockatoos seen or heard within the site during each 30-minute interval was recorded from one hour before to 30 minutes after sunset, i.e. three counts per survey. The total number of birds recorded in the last 30-minute interval at all sites was taken as the estimated population of Yellow-crested Cockatoos in Hong Kong at the time of the survey.

Results and Discussion

Population Size

The estimated population size of the Yellow-crested Cockatoo in the six surveys ranged from 64 to 108 individuals (Fig. 20). This was similar to the reported population size in the late 1990s (Carey et al., 2001). The total number of Yellow-crested Cockatoos remained relatively stable for the first five surveys with a slight decrease in May and July. However, in the last survey, the estimated population dropped to nearly half of that of the previous months. Whether these decreases were related to breeding or other reasons requires further investigation. As there were reports of at least 150 individuals of Yellow-crested Cockatoos (Leven & Corlett, 2004) or even a few hundred of them in Hong Kong (BirdLife International, 2001), and these birds also utilise urban-forest fringes (Leven & Corlett, 2004), the search for other potential roosting sites would be considered in the future.

Fig. 20. Maximum numbers of Yellow-crested Cockatoo recorded at the five survey sites*.



SI = Stonecutters Island; HKU = Pok Fu Lam Road near the University of Hong Kong; HKZBG = Hong Kong Zoological and Botanical Garden; HKP = Hong Kong Park.

* No birds were recorded in Kowloon Park in all surveys.

Our survey results indicate that in 2011, among the five sites surveyed, HKP was the most important roosting site for the Yellow-crested Cockatoo in Hong Kong, as about 88% of the Cockatoos detected in each survey were in HKP. No Yellow-crested Cockatoos were detected in KP during the surveys. A few birds were found at HKU and HKZBG, where their sightings mostly consisted of a single individual or a small flock flying over the site or making transient perches on trees.

Roosting Behaviours

Yellow-crested Cockatoos were observed to fly in circles near the roost tree, perch on branches of tall trees nearby or on exposed vantage points including building roofs, before finally settling on the roost tree (Fig. 21). Similar pre-roosting behaviours of the species were also reported from Taiwan where these birds exist in small feral populations (Lin & Lee, 2006).

Fig. 21. A flock of Yellow-crested Cockatoo perching on a *Bombax ceiba* at dusk in Hong Kong Park.

Yellow-crested Cockatoos were observed to roost in HKP and SI in our surveys. In HKP, the birds roosted on a tall *Bombax ceiba* (木棉). The *B. ceiba* appeared to be defoliated, with at least two cavities and multiple wounds along its trunks and branches. The Yellow-crested Cockatoos were observed checking a cavity on the trunk of this *B. ceiba* during the summer. They were also observed feeding on the fruits/seeds of *Ficus variegata* (青果榕), *Terminalia catappa* (欖仁樹), *Casuarina equisetifolia* (木麻黃) and *Liquidambar formosana* (楓香), and peeling away the petals of flowers of *B. ceiba,* presumably feeding on the nectar of the flowers. In their native ranges, Yellow-crested Cockatoos feed on flowers, fruits, seeds and young leaves (Nandika, 2006; Widodo, 2009), and they also make use of *Bombax* species for nesting and feed on the nectar of their flowers (Widodo, 2009).

The Way Forward

In view of its globally endangered status, we shall continue monitoring the local population of Yellow-crested Cockatoos.

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Rare Lizard Found: Bogadek's Burrowing Lizard (*Dibamus bogadeki*, 香港雙足蜥)

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漁農自然護理署兩棲及爬行動物工作小組最近於周公島再次發現罕見的香港雙足蜥(*Dibamus bogadeki*)。本文就有關發現以及香港雙足蜥的特徵和生態等方面作出簡短的描述。

Introduction

Dibamus bogadeki (Bogadek's Burrowing Lizard, 香港雙足蜥) is a 'legless' lizard belonging to the family Dibamidae (雙足蜥科). It was first discovered in 1987 at Hei Ling Chau and described by I.S. Darevsky in 1992, with the specific epithet '*bogadeki*' named after its first finder, Anthony Bogadek. *D. bogadeki* is a very rare species endemic to Hong Kong. So far, only seven specimens of this species have been found in three outlying islands, namely Hei Ling Chau, Shek Kwu Chau and Sunshine Island, in Hong Kong (Table 1).

Table 4. Details of the specimens of *D. Bogadeki* recorded to date.

Date	Location	Sex	Snout-vent Length (mm)	Tail Length (mm)
1 Apr 1987	Hei Ling Chau	Male	177	40
22 Aug 1992	Shek Kwu Chau	Female	74	26
20 May 1994	Shek Kwu Chau	Female	145	70
8 Jul 1996	Sunshine Island	Female	147	20
2 Jul 1999	Shek Kwu Chau	Male	145	-
27 Sept 2002	Shek Kwu Chau	Female	72	33
23 Sept 2011	Sunshine Island	Female	119	45

The Herpetofauna Working Group of the Agriculture, Fisheries and Conservation Department has been conducting regular surveys for *D. bogadeki* since 2002. In view of the nocturnal and fossorial behaviour of this species, various survey methods including active searching (both day-time and night-time), deployment of pitfall traps and cover boards have been used to search for the lizard. In September 2002, a female individual was found under a wooden plank in a shaded area at Shek Kwu Chau. It was found during a day-time active searching survey. After some nine years of more searching efforts, another female individual was recently found under a cover board deployed earlier in a wooded area on Sunshine Island (Fig. 22).

Fig. 22. *D. bogadeki* found on Sunshine Island.

Taxonomy and Morphology

There are a total of 23 Dibamids recorded to date, of which 22 belong to the Southeast Asian genus *Dibamus* and one to the Mexican genus *Anelytropsis*. Two species of *Dibamus* have been recorded in China: *D. bogadeki* from Hong Kong and *D. bourreti* from Guangxi and Hunan. The genus *Dibamus* measures about 8.6–20.3 cm in snout-vent length (SVL). The female is limbless while the male has small and flap-like hind limbs; the head has vestigial eyes covered by scales, no ear openings, and the nostrils are located on the lateral sides of the snout (Fig. 23); the tail is short with a rounded end; and the scales are smooth and cycloid.

Fig. 23. Head of *D. bogadeki*: scale-covered vestigial eyes, no ear openings and nostrils located on the lateral sides of the snout.

D. bogadeki has a uniform cylindrical body and a rounded snout. The body is lavender to lavender-grey in colour, with irregular ash-grey patches along the body. The tail gradually turns pale towards the tip, with a pale-yellow to white cap at the tip in some individuals. Closely resembling *Ramphotyphlops albiceps* or an earthworm in morphology, the lizard can be differentiated from the former by its tapering tail (vs. a short, blunt tail) and the latter by its scale-covered body (vs. a scaleless, segmented body). Additionally, *D. bogadeki* moves in a typical lizard-like rather than serpentine or worm-like manner.

Fig. 24. *D. bogadeki* hiding partly inside rotting wood.

Ecology and Behaviour

D. bogadeki is a nocturnal and fossorial species inhabiting woodland. It lives in soil, or under covers such as stone, leaf litter or rotting wood on the forest floor. It is known to feed on termites and other small arthropods in captivity. This species is very susceptible to desiccation when exposed to dry air, indicating that it can only survive in a moist and shaded environment. As with many other lizards, it shows autotomy as a self-defence mechanism.

In captivity, *D. bogadeki* was observed to stay mostly under the soil surface during the day. It preferred staying near the bottom of the container and buried as deep as 18 cm below the soil surface. It was also interesting to note that the captive individual was sometimes found wandering inside the crevices of rotting wood on the soil surface at night, presumably hunting for prey such as termites or woodlice (Fig. 24).

To learn more about the behaviour of this species, video recording was carried out to observe its subterranean and surface activities. It was observed that the lizard was most active above ground (or just beneath the soil surface) from late night to after midnight, venturing in and out of the soil or rotting wood hunting for food, but it seldom exposed itself above ground for a long period of time, perhaps to avoid dessication or being hunted by its predators.

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